

## **Web appendix 2:** Description of the telehealth intervention

**Telehealth equipment:** See (1.) in Figure 3. TH participants in Cornwall and Kent received a home monitoring system comprising a base unit (*Tunstall Lifeline Connect+* in Cornwall; *Viterion V100 TeleHealthcare Monitor* in Kent) which is a small device (approx. 20cm x 20cm x 5cm) with an LCD screen to allow textual information to be transmitted to and from participants (e.g. questions about symptoms and self-care; general and disease-specific health information) with simple buttons to allow participants to select from multiple-choice responses. Up to four peripheral monitoring devices were supplied to each participant to allow monitoring of disease-specific biomarkers (pulse oximeter to measure blood oxygenation; glucometer to measure blood sugar; weighing scales; blood pressure monitor). In Newham, telehealth participants received a small set-top box that connects to a television (*Philips Motiva Personal Healthcare System*) allowing symptom questions, educational videos and a graphical history of recent clinical readings to be accessed via a dedicated TV channel, plus an equivalent range of peripheral monitoring devices.

**Allocation of devices:** Participants were allocated up to four peripheral monitoring devices depending on (a.) their known diagnoses of chronic obstructive pulmonary disease, diabetes and heart failure, (b.) local protocols for allocating devices in each WSD Site, and (c.) local clinical override. WSD Sites used different protocols for allocating peripheral devices to participants but across all Sites ‘critical’ devices were allocated as standard for each long term condition unless contraindicated: pulse oximeter for chronic obstructive pulmonary disease, glucometer for diabetes and weighing scales for heart failure. Blood pressure monitors were allocated to nearly all participants regardless of their LTC(s). Participants with multiple conditions received multiple devices. Notwithstanding the general allocation protocols adopted within each WSD Site, allocation of all devices was subject to clinical override by healthcare professionals working with the local WSD Project Team so that some participants did not receive devices otherwise considered appropriate for a particular condition within a particular WSD Site. For example, participants who had diabetes with stable HbA1c levels within acceptable ranges might be considered unlikely to benefit from blood glucose monitoring. Alternatively, chronic obstructive pulmonary disease participants with severely affected breathing might be deemed too impaired to benefit from blood oxygen monitoring. Web figure 1 shows the allocation of monitoring devices by long term condition and WSD Site. Observed differences in allocation of devices across WSD

Sites reflect differences in the standard allocation protocols, differences in case-mix (i.e. patterns of co-morbidities) and differences in the implementation of clinical override.

**Installation of devices:** Engineers only (Kent/ Newham) or engineers plus assistant practitioners (Cornwall) made home visits to install the TH equipment. At the visit the engineer or assistant practitioner gave a demonstration of how to use of the base unit (or set-top box and associated TV channel) and the allocated peripheral devices to take biometric measurements, respond to symptom/ self-care questions, and open other messages / notifications. Participants were supervised through their first measurement session and given written instructions for their telehealth system including step-by-step instructions for each peripheral device, troubleshooting advice and useful contact numbers.

**Calibration of biometric parameters:** The parameters for biometric readings (e.g. blood oxygen levels for patients with chronic obstructive pulmonary disease; blood glucose levels for patients with diabetes; weight fluctuations for patients with heart failure) were initially set in line with existing clinical guidelines for the management of these conditions or were provided by local Specialist Long Term Condition Teams following a test period where patients mutually-exclusive to WSD participants were managed using the telehealth equipment used in the trial (e.g. weight fluctuation for heart failure in Newham). After two weeks of monitoring, parameters for all biometric readings could be re-calibrated for trial participants by the Monitoring Centres in collaboration with GPs based on participants' day-to-day variability and medical history. Further adjustments to parameters could be made during the course of the trial as participants deteriorated or improved.

**Behavioural regimen:** The frequency of measurement sessions was individually-tailored for each participant based on the severity and stability of their condition(s) and their personal preference. The maximum frequency was 5 days per week (Monday to Friday), though multiple measurements per day could be scheduled or they could be put on hold for a short period (e.g. during holidays). The base unit / set-top box reminded participants to take clinical measurements via messages on the screen, a flashing light and (in Kent) an audio alarm. During each session, participants used their allocated peripheral devices (up to a maximum of four) to take biometric measurements. These measurements were presented on-screen to participants. General and condition-specific questions relating to symptoms and self-care behaviour were presented on the base unit (or television) screen and spoken verbally. Example questions include: How are you feeling compared to yesterday? [All conditions]; Are you coughing up sputum today? [Chronic Obstructive Pulmonary Disease]; Have your blood sugars been above your agreed targets? [Diabetes]; Have you taken your

water tablets today? (Yes, No) [Heart Failure]. Depending on responses to the symptom or self-care questions, the base unit (or TV) could automatically provide condition-specific self-management advice (e.g. reminders to monitor and reduce salt intake [Heart Failure]) or general healthy lifestyle advice addressing exercise, nutrition or mood. If changes in self-management were recommended by healthcare professionals in response to out-of-range biometric or patient-reported data (e.g. nutritional changes; titration of medication) the frequency of telehealth measurements sessions could be increased (temporarily) to monitor the effect of the changes. In Newham, the TV channel allowed for more educational opportunities (e.g. up to 45 condition-specific educational videos on the signs, symptoms and management their condition(s) were scheduled into participants care plans over the first 3-4 months to build knowledge). This system also presented ‘quizzes’ to test participants understanding and retention of issues covered in the videos, facilitated interactions between healthcare professionals and participants through message exchanges, and allowed participants to view charts of their biometric readings over the previous month.

**Data transfer:** See (2.) in Figure 3. Data from biometric readings and symptom/ self-care questions were transferred to a Site-specific Monitoring Centre via a secure server using store-and-forward protocols which differed across WSD Sites. In Cornwall data were held on the client device and automatically transferred to the Monitoring Centre at a set time each night. In Kent participants manually initiated transfer of data (prompted by the base unit at the end of each measurement session) or they could opt to delay transfer to a later time. In Newham data were sent automatically at the end of each measurement session. Participants’ biometric and symptom data were not measured or reviewed by healthcare professionals in real-time in any WSD Site.

**TRIAGE/ risk stratification:** See (3.) in Figure 3. Monitoring Centres were staffed by qualified nurses and trained support staff. In addition some Community Matrons and Specialist (respiratory, diabetes or cardiac) Nurses who had trial participants on their caseload were involved in monitoring and could access the Monitoring Centre’s data remotely. Incoming biometric readings were automatically transformed into a traffic light classification of clinical risk (red = high risk; yellow = moderate risk; green = low risk) using Site-specific algorithms and individually-tailored biometric parameters.

In Cornwall red flags indicated that one or more biometric readings (i.e. blood oxygen saturation; blood glucose; weight; blood pressure) were outside the individually-tailored parameters. Yellow flags indicated that one or more biometric readings had not been received by the Monitoring Centre within set time windows around an individually-tailored schedule

(e.g. schedule of Monday, Wednesday and Friday with a 24-hour window). Lack of readings could be triggered by equipment malfunction or a period of absence (e.g. holiday) without informing the Monitoring Centre. Green flags indicated that all biometric readings were received on time and were within individually-tailored biometric parameters.

In Kent red flags indicated that one or more biometric readings were *clearly* outside the individually-tailored parameters. Yellow flags indicated that either one or more biometric readings were *marginally* outside the participant's parameters or had not been received by the Monitoring Centre in accordance with the agreed schedule. Green flags indicated readings that were received on schedule and were all within the individually-tailored biometric parameters.

In Newham red flags indicated that one or more biometric readings were outside the individually-tailored parameters. In this Site, participants with chronic obstructive pulmonary disease were required to complete daily symptom questions and failure to complete these would also generate a red flag. Further, any increase in weight for participants with heart failure would generate a red flag (i.e. participants in Newham did not have tolerances of weight fluctuation as afforded to participants in the other Sites). Yellow flags were not used. Green flags indicated that all biometric readings and participated-reported symptoms (chronic obstructive pulmonary disease only) were received on schedule and were all within the individually-tailored parameters.

**Monitoring Centre review of telehealth data:** See (4.) in Figure 3. Healthcare professionals with access to all current biometric and patient-reported telehealth data, previous telehealth data and selected data from the patient's medical records reviewed the incoming telehealth data in accordance with the attributed clinical risk. Red flags (all Sites) represented a high clinical (or technical) risk with a concomitant likelihood that some immediate action would be required by healthcare professionals (or technical staff). Red flags were reviewed and responded to daily (Monday to Friday). Yellow flags (Cornwall & Kent only) represented a moderate clinical (or technical) risk and an attendant likelihood that some action by clinical (or technical) staff would be required. Yellow flags were monitored and responded to, if required, within 72 hours. In light of persistent failure to transmit biometric or patient-reported readings, attempts were made by the Monitoring Centre or local WSD Project Team to contact the participant to resolve any technical problems or provide further coaching on the use of the equipment. Green flags (all Sites) represented low clinical risk and low likelihood that action by healthcare professionals would be required. Green flags were monitored at healthcare professionals' discretion to identify long-term trends of gradually

deteriorating health that were not yet severe enough to breach the individual's clinical parameters and trigger a yellow or red flag.

**Community Nurses review of telehealth data:** See (5.) in Figure 3. District nurses and Community Matrons who had WSD intervention participants on their existing caseloads were able to access the Monitoring Centre's database remotely via a secure server to review their own patients' telehealth data. These healthcare professionals reviewed patients' data in line with the protocols used in the Monitoring Centre described above.

**Follow-on actions / stepped-care response:** See (6.) in Figure 3. Following review of patient telehealth data by nurses at the Monitoring Centres or in the community, healthcare professionals had a range of follow-on actions available to them depending on their clinical judgement of the severity and urgency of the patient's needs. Due to their role, existing relationship with patients and seniority, community nurses (especially Community Matrons) tended to have greater scope than Monitoring Centre nurses to independently initiate clinical interventions (e.g. arrange a home visit or titrate medicine within certain limits). However, nurses at the Monitoring Centres and in the community could clinically evaluate the patient, offer advice on disease management and refer them to, or arrange appointments with, other healthcare professionals (e.g. District Nurse, Community Matron, Specialist Nurse, GP, hospital Consultant). Healthcare professionals at the Monitoring Centre, in the community and GPs were in close contact and were collectively able to provide a complete stepped-care response for all participants which included, but was not limited to, the following actions:

- (i.) Take no immediate action but keep monitoring.
- (ii.) Contact the patient by phone or via the telehealth base unit/ set-top box to:
  - Request repeat biometric readings.
  - Conduct further clinical assessments by phone.
  - Recommend/ encourage changes in self-management behaviour.
  - Change or titrate medication (in consultation with the patient's GP).
  - Arrange home visit by a Community Matron or District Nurse.
- Refer the patient to their GP, a hospital clinic or the emergency services.
- (iii.) Send the patient's telehealth data to GP for review. In turn the GP may:
  - Review the data and take no action.
  - Phone the patient to discuss the readings.
  - Phone the patient to change or titrate medication (in consultation with the Monitoring Centre and/or community-based healthcare professionals).

- Phone the patient to request they visit the general practice surgery for further assessment.

(iv.) Send the patient's telehealth data to a hospital clinic for review. In turn the specialist nurses or Consultants at the clinic may:

- Review the data and take no action.
- Phone the patient to discuss the readings.
- Phone the patient to change or titrate medication.
- Phone the patient to request they visit the hospital clinical for further assessment.

(v.) Contact the emergency services directly on the patient's behalf to:

- Inform them that a patient with an acute exacerbation is on their way to A&E.
- Request ambulance transfer to A&E.

Some differences were evident across the four Primary Care Trusts providing follow-on care for trial participants. For example, the two Primary Care Trusts within the WSD Kent Site differed from each other in the way they responded to red flags: one sent a fax detailing the parameter breach to the GP within 24 hours of reviewing red flag data, while the other used the secure NHS email to send biometric readings and graphs immediately to the appropriate service (e.g. GP or specialist service).

**Patient-initiated telephone contact:** See (7.) in Figure 3. As part of the telehealth services offered, participants were provided with telephone numbers to contact, free of charge, nurses at the Monitoring Centre or (in some cases) in the community during standard office hours (9.00am-5.00pm) if they were concerned about changes in their biometric readings or symptoms. These nurses would be able to access the patient's telehealth data and make appropriate stepped-care responses (see above).